

FRAGARIA MULTICIPITA, REDUCED TO THE
RANK OF FORMA

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ABSTRACT

The distinctive features of *Fragaria multicipita* Fernald, including small size, multicipital habit, floral aberrations and absence of runners to a greater or lesser degree, are symptoms of strawberry multiplier disease resulting from mycoplasma infection. Direct evidence of the disease in *F. multicipita* plants was obtained through graft inoculation using normal *F. chiloensis* which developed increasingly pronounced multiplier disease-like symptoms after three months. Plants referable to *F. multicipita* were not confined to specialized habitats. The chromosome number of $2n = 56$ obtained from five small multicipital plants representing four locations was the same as that widely reported for the *F. virginiana* complex in North America. These observations suggest that *F. multicipita* is only a diseased form of *F. virginiana*, despite the stability of its distinctive traits in cultivation and the potential adaptive nature of these traits on cool disturbed rivershores. Accordingly, the new combination, *Fragaria virginiana* Duch. ssp. *glauca* (S. Wats.) Staudt f. *multicipita* (Fern.) Catling & J. Cayouette, is proposed.

Key Words: *Fragaria multicipita*, *Fragaria virginiana*, strawberry, taxonomy, disease, mycoplasma, endemism, Québec, Canada

INTRODUCTION

Fragaria multicipita was described by Fernald in 1908 without any discussion of its origin and affinities. Plants referable to it were not found again until 1992 (Catling, 1993). Some of the characteristics of *F. multicipita* are suggestive of a subarctic or ice front relict. The cushion-like habit increasing temperature and resisting abrasion, parabolic flowers, and the genotypic dwarfing are features of plants of cold, exposed environments (Savile, 1972). The multiple crowns accumulate debris more readily than the more familiar fewer-crowned plants growing nearby (Catling, pers. obs.). These potential adaptations and occurrence in a specialized rivershore environment, as well as a suggestion of stability of distinctive traits in uniform garden culture, are consistent with species rank (Catling, 1993) and the concept of an ice front relict. Such speculations can become attractive and some botanists have conjectured (pers. comm.) that the small size and relict nature of *F. multicipita* make it a potential diploid or tetraploid progenitor of the North American octoploid *Fragaria virginiana* complex.

On the other hand Reed (1966) speculated that "*F. multicipita* may be virus-infected plants," and few authors have perpetuated the name (Catling, 1993). As noted previously, a decision on the appropriate rank required more study (Catling, 1993). Here we report on some recent studies including: (1) the nature of distinctive morphological traits, (2) the possibility of disease being a causal factor, (3) consideration of habitat aspects, and (4) chromosome numbers.

METHODS

Morphological Observations

Material of *Fragaria* from throughout the Gaspé peninsula was maintained in cultivation in the glass house in Ottawa over a two-year period. Included were 22 plants referable to *F. virginiana* Duch. ssp. *virginiana* with spreading hairs on the scapes and petioles, and 30 referable to *Fragaria virginiana* ssp. *glauca* (S. Wats.) Staudt (including *F. virginiana* var. *terrae-novae* (Rydb.) Fern. & Wieg.) with ascending hairs on scapes and petioles, and 10 plants referable to *F. multicipita* Fern., including some with spreading petiole hairs and some with ascending petiole hairs. These plants were grown in similar soil mix in similar pots and were subject to similar watering and light regimes. The extent to which distinctive features of the plants at the time of collection were maintained in cultivation was noted.

Evidence for Disease as a Causal Factor

The literature on strawberry diseases was surveyed to determine which diseases might produce a small-leaved, bushy strawberry lacking runners. Direct evidence of mycoplasma infection was sought through standard leaflet graft inoculation (Converse, 1987a). This technique involved cutting petioles of test plants into a "V" shape and inserting them into the cut petiole of an indicator plant established as appropriate through previous experimentation. Five normal *F. virginiana* plants including ssp. *glauca* (N2, N9, N15) with ascending hairs and ssp. *virginiana* (N8) with spreading hairs, and 3 multicipital plants (including one with spreading hairs (M15), and one with ascending hairs (M23)) were grafted to normal *F.*

chiloensis plants. Vouchers of material used in graft inoculation were placed in DAO and MT.

Habitat Aspects

Field work in August 1993 was directed to determining whether or not plants referable to *F. multicipita* were confined to specialized habitats, and the extent to which they occurred with other *Fragaria* taxa.

Chromosome Numbers

Young root tips of plants used for cytological study (Tables 1 and 2) were collected and pre-treated in water, refrigerated for three hours, fixed in Farmer's fixative (glacial acetic acid: absolute

Table 1. Locations, DAO voucher number, plant appearance, collection number, petiole hair orientation and root tip chromosome determination for various strawberry plants collected along the Rivière Ste.-Anne in Gaspé, Québec, that were used in the study.

Location	Voucher no.	Appearance	Coll. no./petiole orientation	2n =
1. 49°02'55"/66°28'50" gravel bar on W side of Rivière Ste.-Anne 9 km SSE of Ste.-Anne- des-Monts	682393	multicipital	M11/ascending	ca. 56
	682394	multicipital	M10/ascending	56
	686462	normal	N2/spreading	56
	686451	normal	N10/ascending	56
	none	normal	N8/spreading	none
2. 49°00'50"/66°28'15" gravel bar on W side of Rivière Ste.-Anne 13 km SSE of Ste.- Anne-des-Monts	686473, 74, 77, 92	multicipital	M15/ascending	56
	686461	normal	N15/ascending	ca. 56
3. 48°55'20"/66°06'30" gravel roadside on W side of hwy 299 at Chute du Diable, Ri- vière Ste.-Anne	686472, 78, 91	multicipital	M9/ascending	56
	686449	normal	N9/ascending	ca. 56
4. 49°05'40"/66°30'20" gravel bar on W side of Rivière Ste.-Anne 4 km SSE of Ste.-Anne- des-Monts	686475	multicipital	M24/ascending	56
	686450	normal	N1/ascending	56
	none	multicipital	M23/spreading	none

Table 2. Additional notes on particular voucher specimens prepared from cultivated plants.

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686475. Plants with few runners less than 10 cm long developed over 50 crowns as did the daughter plants from short runners, but leaflets remained less than 20 mm long and petioles less than 7 cm long after two years in culture.
- 686472, 686478, 686491. After culture for one year, developed over 100 crowns but retained small leaflets less than 28 mm long, and short petioles less than 10 cm long. Inner floral parts of many, but not all flowers, developed into new plants and petals in some cases were green, reduced and ascending.
- 686473, 686474, 686477, 686492. After two years in cultivation, developed into a "bush" with over 150 crowns, but never developed runners and retained its small leaflets less than 32 mm long and short petioles less than 12 cm long.
682393. After two years in cultivation, developed into a "bush" with over 150 crowns, but never developed runners and retained its small leaflets less than 27 mm long and short petioles less than 7 cm long. The petals of many flowers were greenish and ascending, but white, spreading petals were produced on the same plant.
682394. After two years in cultivation, developed numerous fragile runners to 20 cm long but retained its small leaflets less than 20 mm and short petioles less than 7 cm long. The petals of many flowers were greenish and ascending but white, spreading petals were produced on the same plant.
- 686449-51, 686461-2. These plants, referable to *F. virginiana* ssp. *glauca* (S. Wats.) Staudt, had leaflets 30-80 mm long, petioles 10-20 cm long, less than 5 crowns and stout runners 20-72 cm long. There were no floral anomalies.
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ethanol, 1:3) for 12 hours and stored in 70% ethanol. Staining was done in alcoholic hydrochloric acid-carmin (Snow, 1963). Chromosome counts were made on the best cells in late prophase or early metaphase. At least two cells from each collection were examined. Voucher herbarium specimens for both morphological observations and chromosome counts were placed in DAO and MT.

RESULTS AND DISCUSSION

Morphological Observations

Small multicapital plants with petioles less than 12 cm and leaflets 5-32 mm, referable to *F. multicapita* when collected, re-

tained their small size and multicipital habit for two years in cultivation, although some developed into dense clumps with over 200 ramets. The adjacent few-crowned plants referable to *F. virginiana* Duch. ssp. *virginiana* with spreading hairs on the scapes and petioles or *Fragaria virginiana* ssp. *glauca* (S. Wats.) Staudt with ascending hairs on scapes and petioles, also retained their larger size, with petioles 10–20 cm and leaflets mostly 30–80 mm long, over the two year period (see also Table 2). It was noted previously that the stability of distinctive traits of *F. multicipita* in culture was consistent with its recognition (Catling, 1993). As might be expected, 10 multicipital plants marked in 1992 had also retained their distinctive features in nature one year later.

Multicipital plants always had relatively short leaflets less than 32 mm long and petioles less than 15 cm, but they ranged from no runner production, to some that produced few runners less than 10 cm long, to some that produced runners to 25 cm long. Only the larger multicipital plants produced runners but not all of them did so.

No additional distinctive morphological features were found to be associated with the *F. multicipita* plants, with the exception that the majority of plants from three localities, which were not flowering when collected, developed aberrant flowers with either petals green, reduced in size, more or less connate and ascending, or petals normal but inner floral parts developing into new plants. No such aberrations were present elsewhere in the glasshouse collection, nor were they observed in nature. Indeed such aberrations are rare, so to find them in approximately half of the *F. multicipita* plants, from three out of six known, suggested that the plants were diseased.

Variation in hair type on petioles of *F. multicipita* plants suggests these plants may not belong to a monophyletic taxon. Ascending hairs on petioles ally *F. multicipita* to *F. virginiana* ssp. *glauca*, but at two of the six localities the small, multicipital plants had spreading hairs, thus allying them to ssp. *virginiana*. Such pubescence characteristics in *Fragaria* are stable in cultivation and mostly consistent within plants and mostly not intergrading. Although a species may have geographically based infrataxa distinguished by pubescence orientation, as in *F. virginiana* or *F. chiloensis*, the appearance of both kinds of pubescence within a putative, narrowly confined endemic was a surprise.

Disease as a Causal Factor

In strawberries, small size, multicipital habit, and absence of runners to a greater or lesser degree, are well documented symptoms of multiplier and witches'-broom diseases which are associated with mycoplasma infection (viz. Boone, 1970; Converse, 1987b; Mass, 1984). Thus the distinctive morphology of *F. multicipita* may be simply a consequence of disease. The floral aberrations, noted above as the only other distinctive traits of plants referable to *F. multicipita*, are a result of green petal disease caused by a leafhopper-borne mycoplasma (viz. Chiykowski and Craig, 1975; Cousin et al., 1970; Mass, 1984).

The plants referable to *F. multicipita* were also the most difficult to maintain in cultivation. Approximately half died over the two year period, whereas the loss of plants referable to either ssp. of *F. virginiana* was less than 1%.

Normal *F. chiloensis* plants with grafted leaves from multicipital plants developed symptoms of multiplier disease three months after inoculation. These symptoms included reduced leaf size, shorter runners and proliferation of the crown. The symptoms became increasingly conspicuous in the new growth with increased time after three months. The normal *F. chiloensis* with grafted leaves from normal plants of *F. virginiana* ssp. *virginiana* or ssp. *glauca* collected near multicipital plants produced no disease symptoms. The fact that the multicipital and related characteristics could be transmitted from multicipital plants to normal plants suggests very strongly that *F. multicipita* is a pathogen-induced taxon.

Habitat Aspects

Additional field study revealed occurrence of plants referable to *F. multicipita* on a gravel roadside (Table 1), where no other endemic, disjunct, or unusual plants were present. At each site where *F. multicipita* occurred (Table 1), plants referable to *F. virginiana* ssp. *virginiana* and/or *F. virginiana* ssp. *glauca* were also present. Plants referable to *F. multicipita* could not be found in specialized alpine, subalpine or serpentine habitats. The river bars do represent a specialized habitat, but are also occupied by "weedy" species (Catling, 1993). The distinctive features of *F. multicipita* (or the traits of the diseased plants), i.e. small size and

bushy form (see above) may adapt them to the cool rivershore environment where wind and water are important factors, thus explaining their increased prevalence along the rivershores. Alternative, but not mutually exclusive, explanations include the possibility that the rivershore habitat is more conducive to the spread of the disease and/or that plants in this habitat are more susceptible.

Chromosome Numbers

The octoploid chromosome number of $2n = 56$ obtained from five multicipital plants representing four locations (Table 1) is the same as that widely reported for the *F. virginiana* complex in North America (Staudt, 1962; Reed, 1966). Plants referable to *F. virginiana* ssp. *virginiana* or *F. virginiana* ssp. *glauca* that were growing intermixed or within one metre of the *F. multicipita* plants also had a chromosome number of $2n = 56$ (Tables 1 and 2).

CONCLUSIONS

Accepting the distinctive morphology of *F. multicipita* as simply a consequence of disease seems to be the most appropriate decision since: (1) the relationship between diagnostic traits and disease is well documented, (2) other characteristics of the taxon such as the difficulty of culture and the high incidence of floral aberration are also associated with disease, (3) there are no distinctive morphological traits that are not associated with disease, (4) multicipital and related characteristics were transmitted from multicipital plants to normal plants, (5) plants referable to *F. multicipita* are not confined to specialized habitats and their prevalence along cool rivershores may be explained in terms of the adaptive nature of traits of diseased plants, (6) the plants referable to *F. multicipita* always occurred with plants referable to *F. virginiana*, (7) its chromosome number is the same as that of the widespread octoploid *F. virginiana*, despite remarkable differences in plant size which result in the expectation of a lower chromosome number. Consequently we propose the new combination:

***Fragaria virginiana* Duch. ssp. *glauca* (S. Wats.) Staudt f. **multicipita** (Fern.) Catling & J. Cayouette, *stat. et comb. nov.*
BASIONYM: *Fragaria multicipita* Fernald, *Rhodora* 10: 49–50. 1908. Type: QUEBEC: Gaspé Ouest Municipality: Cap Chat Township: gravelly and sandy beaches and bars of the River Ste. Anne-des-Monts, 14–17 July 1906, *M. L. Fernald* and *J. F. Collins* 230 (Holotype: GH!; Isotype: GH!).**

From examination of the holotype of *Fragaria multicipita* (GH), as well as reference to Fernald's original description, where petioles are described as "appressed silky," it is clear that *Fragaria multicipita* has to be included within the ssp. *glauca* when transferred to *F. virginiana*. This leaves the small, multicipital plants with spreading hairs without a name. We propose not to provide a name for these since it is conceivable that any species of *Fragaria* could assume this morphology with infection by certain mycoplasmas. The advantage in retaining a rank for the name *multicipita* is that it enables the classification system to account for the unusual morphology, which would otherwise continue to raise questions not readily answerable by a systematist. A similar situation exists within the eastern North American *Trillium grandiflorum* (Michx.) Salisb., where the plants with green striped petals, which are sometimes considered as a consequence of mycoplasma infection (e.g., Chinnappa, 1982; Hooper et al., 1971; Pringle, 1970), are accorded the rank of *forma*, thus providing a name and some associated information on an aberration that is frequently an object of questions.

The status of *F. multicipita* does not upset the concept of the Gulf of St. Lawrence region as a region of endemism since there are numerous other endemics known from the region (Catling, 1993; Catling & Cayouette, 1994). Whereas there are other taxa described by Fernald that were later found to be diseased plants or freaks, such as *Carex elachycarpa* Fern. and *C. josselynii* (Fern.) Mackenzie (Reznicek & Ball, 1979), the fact remains that many of the taxa he described have been found, through recent detailed study, to be worthy of recognition as hybrids (e.g. *Juncus* × *oro-nensis* Fern., *Eleocharis* × *macounii* Fern.) or at, below or even above the ranks he ascribed to them (e.g. *Malaxis bayardii* Fern., *Cleistis bifaria* Fern.). Thus in the broad context, the fate of *F. multicipita* does not reduce the significance of Fernaldian taxa.

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